

transmit power would be based on the current observation of the forward link and some past history of transmit power. This method would work well for those network applications where mobility is not exercised very often, since mobiles will have derived a reasonable estimate of their effective link path loss.

The current open loop estimate is based on total received power within the allocated bandwidth. It may be possible to improve on this estimate by utilizing information conveyed by both the received pilot E_c/I_o and forward packet data channel error rate. That is, the pilot E_c/I_o is a better indicator of cell load than total received power and this measure may yield a better open loop estimate. In addition, the average error rate observed on the forward packet data channel coupled with knowledge of the forward power allocation and data rate provide additional information to the mobile. Use of this data may also improve the open loop estimate.

Load Control

Since the packet data service is designed to support multiple data rates, the load presented to the system by a single packet data user is a function of the data rate employed. For example, a single user transmitting at 19.2 kbps is equivalent to two 9600 bps users, for 4800 bps users, etc. Thus, the Erlang variations in the cell load due to packet data traffic can have a significant impact on other traffic types such as voice and circuit switched data. Load control may be exercised by the base station in a dynamic manner to effectively manage the capacity in a fair and intelligent manner. Further, the efficiency of the packet data service can be improved using load management.

In the case of mixed traffic (i.e. voice and data users sharing a common RF channel), the load control algorithm employed may be different than with a pure packet data service. This is because the concept of service availability is totally different for voice and data users. The voice user expects a certain fidelity to be maintained over the duration of the call. The data user perceives delay/throughput as the measure of quality. In the mixed traffic scenario, it is important to insure that voice traffic call quality is not degraded by the packet data users. The base station must insure that the average load is maintained at a point where statistical variations due to both data and voice users do not significantly increase the frame error rate of voice users. It was shown that instability due to voice activity occurs at fractional cell loads of roughly 75%; depending upon the packet data traffic characterization, network instability may occur at lower fractional cell loads.

For a pure packet data service, load control can be used to improve the efficiency of the network. While the number of receiving elements in the base station ultimately limits the number of simultaneous transactions, the variable data rate nature of the packet service may become the limiting factor in some situations. As an example, suppose the network is designed to achieve a given average load of 20 simultaneous transactions at an average rate of 4800 bps per user. Coverage and availability are generally achieved when the system load does not exceed this. This capacity can be easily exhausted, without incurring blocking due to lack of servers, by enabling a few high data rate transactions. If the average load is allowed to exceed the design, then some users may experience lower availability. Depending upon the statistics of the traffic mix, this may or may not result in acceptable performance.

Load control can be implemented using the busy/idle status flags conveyed on the forward packet data control

channel. Several different strategies exist, depending upon the traffic mix, data rates supported, number of receivers and service availability target. Some of these are outlined below:

1. Case of Idle Receivers:

- (a) If the average load is low, the maximum permitted data rate can be increased, and/or additional channels may be enabled.
- (b) If the average load is high, the cell may lower the maximum permitted data rate to achieve the desired load, and/or lower the total number of available channels.
- (c) If the average load is at the desired operating point and idle channels exist, the cell may set the busy flags for all idle channels in order to maximize the throughput of the current users at the expense of blocking accesses. Conversely, the cell may lower the maximum permitted data rate (i.e. reduce the load) and allow more users on. This has the effect of reducing the peak-to-average delay observed by all users for a given number of channels.

2. Case of Busy Receivers:

- (a) If the average load is low, the maximum permitted data rate may be increased.
- (b) If the average load is high, the maximum permitted data rate may be decreased.

Soft Handoff

In a CDMA packet data network, the necessity for soft handoff is questionable since the RLP is designed to efficiently recover from error events. Depending upon the frequency and statistical characterization of error events, soft handoff may improve network efficiency and throughput. The economic and performance tradeoffs associated with providing this capability for packet data traffic are not entirely clear. The cost of providing this capability may be prohibitive for some operators and/or certain mobiles designed specifically for a given application. Nevertheless, we present a proposed scheme which could be adopted if desired.

One of the key problems with soft handoff in a packet data service has to do with synchronizing the forward packet data channel. In circuit switched applications the traffic channels being transmitted by the different cells are synchronized so that the mobile is able to coherently combine the signals prior to detection and decoding. This ability can provide enormous benefits to the network. The fundamental problem in packet data is the outbound message queues in each of the serving cells are not necessarily synchronized, and that requiring this may prove costly. In the event that synchronization is possible, soft handoff on the forward link can be made functionally equivalent to that used on existing traffic channels, although the management functions may be different. If synchronization is not possible, then a form of switched diversity can be used at the mobile to effectively emulate soft handoff.

Mobiles make the determination as to whether they are in handoff. That is, the mobile compares the pilot E_c/I_o received from nearby base stations and compares this to the handoff threshold. If the threshold is exceeded, the mobile issues a request to the serving base station to be placed into soft handoff is desired. The serving base station arranges this with the switch and then places the mobile into soft handoff given that the request is granted. At this point the mobile knows which forward packet data channels to demodulate.